APEX PROFILER USER MANUAL

Applies to Serial Number:	Revision Date: 02/21/16
7562	Customer name **IMR**
	Job Number: 30449
	Firmware Revision Apf9iSbe41cp7.2.3-Optode-Flbb-Flash-102815-BML
	Features:

Features:

APF9I Controller
Park and Profile
Deep Profile First (DPF)
Air pump energy consumption limit
Time of Day profile control
Non-modal behavior

Depth Table 67
FLBB-AP2
Aanderaa Oxygen Sensor (Optode)
Some with N2 compensator

I.   Alkaline/Lithium Battery Warning

APEX profilers (also referred to as *floats*) can use either alkaline manganese dioxide (alkaline) or lithium primary (l*ithium*) batteries as a power source, both of which can be hazardous.

<u>Alkaline batteries</u>

There is a small but finite possibility that batteries of alkaline cells will release a combustible gas mixture. This gas release generally is not evident when batteries are exposed to the atmosphere, as the gases are dispersed and diluted to a safe level. When the batteries are confined in a sealed instrument mechanism, the gases can accumulate and an explosion is possible.

Teledyne Webb Research has added a catalyst inside of these instruments to recombine hydrogen and oxygen into H_2O, and the instrument has been designed to relieve excessive internal pressure buildup by having the upper end cap release. However, there is no way to completely eliminate this hazard, so care should be taken when opening previously sealed floats.

<u>Lithium batteries</u>

Lithium batteries pose an even greater risk, since contact with water can result in the battery releasing flammable gases and igniting. Of course, APEX floats are designed to be completely sealed during deployment, but there is always a small possibility that a leak has occurred. For this reason, it is recommended that Lithium batteries **not** be used on APEX profilers that are intended to be recovered.

In general, Teledyne Webb Research knows of no way of completely eliminating these hazards. The user is warned, and must accept and deal with this risk in order to use this instrument safely as so provided. Personnel with knowledge and training to deal with this risk should seal or operate the instrument. Teledyne Webb Research disclaims liability for any consequences of combustion or explosion.

II.   APF9I Operations Warning for APF9A Operators

The "look and feel" of the APF9I operator interface is quite similar to the APF9A operator interface. However, there are some differences of which you should be aware:

- The APF9I uses <u>minutes</u>, not <u>hours</u>, for mission parameter timing intervals
- Air bladder inflation is the only visible evidence that the float passed the self-test and is ready for deployment. The APF9I does not make six test transmissions that can be detected with an external RF receiver.
- The maximum air bladder pressure is (and should be) higher in the APF9I (6.2 inHg) than in the APF9A (5.3 inHg). This is to assure robust connectivity for the Iridium antenna.

III.   Maximum Operating Pressure

APEX profilers have a maximum operating pressure of 2000 dbar (2900 psi).   However, for shallower applications, thinner walled pressure cylinders can be used.   These cylinders have a reduced pressure rating, but less mass, which allows them to carry a larger battery payload. Three cylinder pressure ratings are available:

- 2000 dbar   maximum pressure rating
- 1500 dbar   battery payload typically 14% greater than with 2000 dbar cylinder
- 1200 dbar   battery payload typically 28% greater than with 2000 dbar cylinder

For example, if an APEX profiler is specified by the customer for 1400 dbar maximum (profile) depth, then the 1500 dbar cylinder would normally be used.

<u>**CAUTION:**</u>

If you will be:

- Exposing floats to significant hydrostatic pressure during ballasting or testing
- Re-ballasting and re-programming floats for a depth greater than the original specification

Please contact TeledyneWebb Research to confirm the pressure rating of specific floats. Do not exceed the rated pressure, or the hull may collapse.

IV.   Evaluating the Float and Starting the Mission

APF9I profilers use either *modal* or *non-modal* controllers. Since the type of controller determines the behavior of the Reset Tool, it is extremely important to determine which type of controller is loaded on the profiler. The controller described in this manual is *non-modal*, meaning that the float will be shipped in Pressure Activation mode, and the Reset Tool can be used to toggle the float between Pressure Activation mode, and starting a new mission. This contrasts with *modal* floats, in which the Reset Tool is always used to start a mission (and not to put the float in Pressure Activation mode).

 The motivation for using non-modal controllers is to reduce the risk of launching floats that do not start missions. For non-modal controllers, the float will always run a mission when launched: either because of Pressure Activation, or because the float is already running a mission. This is not true for 'modal' controllers, which could be launched without either Pressure Activation, or without a mission running. From this point on, this manual describes only non-modal behavior.

 If physically connected to the float (using a communication cable between a PC and the float, as described in the section "Connecting a Terminal" at the end of this manual) it is also possible to put the float into an 'inactive' state. Once connected, the 'i f' (freeze command) immediately makes the float hibernate, powering it down and placing it in an 'inactive' state. The 'i * i' command also places the float in an 'inactive' state, although the float will remain awake and communicating. Entering a 'q' command (or not communicating for ... minutes) will then place the float into Pressure Activation mode. Either way, the easiest way to determine the state of the connected float is via the 'i * s' command, which gives the state as well as any mission time.

Another non-modal float behavior is that if any corrupted or ill-formed data is received from the CTD sensor, then the mission is automatically started (if not already running). This ensures that the user will be notified of the problem. However, this presents another risk when leaving a float in the lab, connected to a power-source, but with no pressure sensor or piston-position sensor attached. If the float wakes (on the two hourly interval) and detects no CTD data, a mission is automatically started. This extends the piston, but with no piston-position sensor attached there is a risk of extending the piston too far.

The following sections, "Manual Deployment with the Reset Tool" and "Pressure Activation Deployment", provide operational summaries for the two possible deployment scenarios. Both sections refer to self tests conducted by the float and the float function checks performed by the operator.

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Teledyne Webb Research strongly recommends testing all APEX Profilers on receipt by the customer and <u>before</u> deployment to ensure no damage has occurred during shipping.

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## A.	Manual Deployment with the Reset Tool

Since the Reset Tool toggles between Pressure Activation mode and starting a new mission, start a new mission by first ensuring that the float is in Pressure Activation mode, and then hold the Reset Tool over the marked location on the pressure case for approximately 3 seconds. Remove the Reset Tool only after you hear the air pump activate.

The float will run a brief self test and place itself in a state of maximum buoyancy. This is the Mission Activation phase. During this time the operator should verify proper function of the float (see "Mission Activation and Operator Float Function Check"). The float will telemeter its GPS location and the mission parameters during the Mission Prelude phase. Six hours is typical; the duration of the Mission Prelude can be set by the operator. The piston will be fully extended and the air bladder will be fully inflated during the Mission Activation phase. At the conclusion of the Mission Prelude the float will retract the piston, deflate the air bladder, and begin its pre-programmed mission.

Manual Deployment Summary:

- Ensure that the float is in Pressure Activation mode before toggling
- Toggle to start a new mission by holding the Reset Tool over the RESET label
- Mission Activation
    - Air pump runs for 1 second
    - Self tests conducted
        - The self tests can be monitored if a communication cable is connected, see "Connecting a Terminal"
    - If the float passes the self tests:
        - Piston is fully extended
        - Air pump is cycled on and off until the air bladder is fully inflated
        - Air bladder inflation is the only easily verified indication that the float has pass the self tests and is ready to deploy
- Mission Prelude
    - Float telemeters GPS location and mission parameters
        - The telemetry interval is set by the operator, Parameter Mhr
    - Mission Prelude duration is typically 6 hours

The float can be deployed after the Mission Activation phase and confirmation of proper float function have been successfully completed. We advise waiting until the air bladder is fully inflated before deploying the float.

If the float fails the self tests the piston will not extend and the air bladder will not inflate. The float should not be deployed.

B.   Pressure Activation Deployment

Non-modal floats are shipped in Pressure Activation mode, so no operator action is required to set this mode. In this mode, the float checks the pressure every two hours. If the measured pressure is greater than 25dbar the float starts its mission. Otherwise, the float moves the piston to the position indicated by mission parameter 'P-Activation piston position' (if not already there) and goes to sleep for another two hours.

Note that this behavior does present some risk. For example, if 'P-Activation piston position' was set to a value that would make the float bouyant at the surface (e.g. around 100) then a float launched in this mode would never sink, and would never activate (start) its mission. For this reason, 'P-Activation piston position' is typically set to around 16. At this setting the float would sink below 25dbar, and consequently start its mission.

 Pressure Activation Deployment Summary:

- Deploy the float (no toggling is required since the float is delivered in Pressure Activation mode)
- Pressure Activation
  - Pressure is measured every 2 hours
  - Pressure in excess of 25 dbar triggers
    - Full piston extension
    - Transition to Mission Prelude
- Mission Prelude
  - During ascent the float looks for a satellite at each telemetry retry interval (Parameter Mhr)
  - Detection of a satellite (surface) triggers
    - Full air bladder inflation
  - Float telemeters GPS location and mission parameters
    - The telemetry interval is set by the operator, Parameter Mhr
  - Mission Prelude duration is typically 6 hours
  - **In this particular version of the APF9I firmware, the Mission Prelude will terminate after the first successful telemetry cycle (or it will time out after 9 hours)**

C.   Mission Activation and Operator Float Function Check

1) Secure the float in a horizontal position using the foam cradles from the shipping crate.

2) The minimum internal temperature of the float is -2.0°C. If necessary, allow the float to warm up indoors before proceeding.

3) Remove the plastic bag and three (3) plugs from the CTD sensor as shown in the two images below.

4) Carefully remove the black rubber plug from the bottom center of the yellow cowling as shown in the image below. This will allow you to verify air bladder inflation in the steps below. **Use only your fingers to remove the plug. Tools may puncture or otherwise harm the bladder. <u>Be sure to replace the plug before deployment!</u>**

   <u>Note</u>: It can be difficult to replace the plug when the air bladder is fully inflated. We suggest that you reinsert the plug before the bladder is fully inflated. The plug prevents the entry of silt into the cowling in the event the float contacts the sea floor.

5) Start a Manual or Pressure Activated Deployment. This will trigger the Mission Activation self tests. Where applicable, the description below indicates where the two versions of the self tests differ.

Verify by ear that the air pump is activated for approximately 1 second.

DO NOT DEPLOY THE FLOAT IF IT DOES NOT BEHAVE AS DESCRIBED BELOW. FLOATS THAT DO NOT PASS THE SELF TESTS SHOULD NOT BE DEPLOYED. CONTACT TELEDYNE WEBB RESEARCH FOR ASSISTANCE.

6) The float will conduct self tests for approximately 15 seconds. Progress and diagnostic messages will be displayed if a terminal is connected to the float (see "Connecting a Terminal" for additional information).

7) If the float passes the self tests:

Manual Deployment: If not already fully extended, the float will fully extend the piston. This process may require up to 25 minutes. The oil bladder will expand during this time. The float will also fully inflate the air bladder.

Pressure Activated Deployment: If not already fully retracted, the float will fully retract the piston. This process may require up to 25 minutes. The oil bladder will deflate during this time. The float will also deflate the air bladder.

The volume of oil in the bladder is difficult to detect by hand. You may be able to hear the pump by placing your ear against the hull. Air bladder inflation can be easily verified as described in Step 4.

8) <u>Manual Deployment</u>: Once the piston is fully extended the float enters the Mission Prelude phase. During this phase it will telemeter its GPS location and the mission parameters. Check for air bladder inflation by sticking your finger (**not a tool!**) through the hole in the bottom of the yellow cowling as described in Step 4 above. **Don't forget to replace the plug before deploying the float.**

The duration of the Mission Prelude is set by the operator. 6 hours is typical. At the end of the Mission Prelude the float will deflate the air bladder, retract the piston, and begin the first descent of the programmed mission.

<u>Pressure Activated Deployment</u>: Once the piston is fully retracted the float will enter the Pressure Activation phase. During this phase it will check the pressure every two hours, hibernating in between. The float will not enter the Mission Prelude phase until it detects a pressure in excess of 25 dbar. There will be no telemetry nor inflation of the air bladder until the Mission Prelude phase begins and the surface is detected.

When the trigger pressure is detected the float will extend the piston and begin the Mission Prelude. During this phase it will attempt to locate a satellite while ascending. Once a satellite is detected (surface detection), the float will telemeter its GPS location and the mission parameters for the balance of the Mission Prelude. The duration of the Mission Prelude is set by the operator. 6 hours is typical. At the end of the Mission Prelude the float will deflate the air bladder, retract the piston, and begin the first descent of the programmed mission.

In this particular version of the APF9I firmware, the Mission Prelude will terminate after the first successful telemetry cycle (or it will time out after 9 hours)

9) The float is ready to deploy.

C.   Notes and Caveats

Self Tests: During the self tests the float checks:

- The internal vacuum
- Communication with the CTD
- The internal alarm timer settings

If any of the self tests fail the float will abort the mission. The clearest indication to the operator that this has occurred is the failure of the float to make the initial 6 ARGOS transmissions at 6 second intervals.

If you do not detect these Mission Activation transmissions with the Cat's Meow, DO NOT DEPLOY THE FLOAT!

Manual Deployment: In the case of a Manual deployment, if the float is not deployed before the completion of the Mission Prelude phase,

RESET the float again and wait for it to complete the Mission Activation phase and begin the Mission Prelude before you deploy it.

Pressure Activated Deployment: In the case of a Pressure Activated Deployment, the operator is necessarily absent when the float begins the Mission Prelude. This means the operator does not have the opportunity to check the air bladder for leaks that a Manual Deployment offers.

For this reason we strongly recommend that you manually inflate and check the bladder before starting a Pressure Activated Deployment.

Telemetry Testing: During the Mission Prelude the float will telemeter data to the host server. **The float must have a view of the sky to telemeter successfully**. Starting a manual deployment, allowing the float to complete several telemetry cycles, and confirming the reception of the telemetered files at the host server and back at the float (leave the communications link connected) constitutes a valid and easily conducted test of the full communications system.

V.   Deploying the Float

1)   Pass a rope through the hole in the plastic
     damper plate, which is shown in the image at
     right. The rope should fit easily through the hole
     and be capable of supporting 50 kg (100 lb).

2)   Holding **both** ends of the rope bight, carefully
     lower the float into water. The damper plate is
     amply strong enough to support the weight of
     the float. However, do not let rope slide rapidly
     through the hole as this may cut the plastic disk and release the float prematurely.

3)   Take care not to damage the CTD or the Iridium antenna against the side of the ship while
     lowering the float.

4)   **Do not leave the rope with the instrument.** Once the float is in the water, let go of the
     lower end of the rope and pull on the top end slowly and carefully until the rope clears the
     hole and the float is released.

     It may take several minutes for the cowling protecting the bladder to fully flood with water
     and the float may drift at an angle or even rest on its side during this period. This is normal
     behavior and not a cause for concern.

5)   Manual Deployment: The float will remain on surface for the duration of the Mission
     Prelude.

     Pressure Activated Deployment: The float will sink immediately. It will return to the
     surface within 3 hours and begin the Mission Prelude after detecting a pressure in excess of
     1500 dbar.

VI.   Park and Profile

The APF9I float can be set to profile from a maximum depth (Profile Depth) after a programmable number (N) of profiles from a shallower depth (Park Depth). Special cases are conducting all profiles from either the Profile Depth or the Park Depth. The latter is an important special case that can be selected by setting N = 254. This will cause all profiles to start at the Park Depth; the programmed Profile Depth is ignored. Between profiles the float drifts at the Park Depth.

Terminology:
- Park Depth   Intermediate depth at which the float drifts between profiles and from which the float profiles in cycles not evenly divisible by N.
- Profile Depth   Maximum depth to which the float descends from the Park Depth every Nth cycle and from which each Nth profile is conducted.
- Down Time   Programmed time-limit for descending from the surface and drifting at the Park Depth. Down Time is commonly set to 10 days or to 10 days less the Up Time.
- Up Time   Programmed time-limit for ascending from the Park or the Profile Depth and drifting at the surface while transmitting the data acquired during the profile. Up Time is typically set between 12 hours and 20 hours, increasing with the amount of data to be transmitted per profile. The latitude of the deployment also matters; ARGOS satellites are in polar orbits, so the number of satellite passes per day increases with latitude.
- Ascent Rate   The ascent rate of the float is maintained at or above 8 cm/s. The float extends the piston by a user specified amount to add buoyancy when the ascent rate falls below this threshold.

A.   Profile Ascent Timing

Profiles from the Park Depth begin when the operator programmed Down Time expires. The float extends the piston by an operator programmed initial amount and begins the ascent.

When a profile is to begin from the Profile Depth, the float will retract the piston and descend from the Park Depth an operator programmed interval before the expiration of the Down Time. This interval, Parameter Mtj, Deep-profile descent time in hours, provides the additional time needed to descend to and profile from the Profile Depth without losing significant surface time, the period when data from the profile are transmitted.

B. Profile and Profile Cycle Schematics

Down Time   Up Time

Surface

Park Depth

Profile Depth

Time

N = 1
Deep Profile every cycle

N = 3
Deep Profile every third cycle
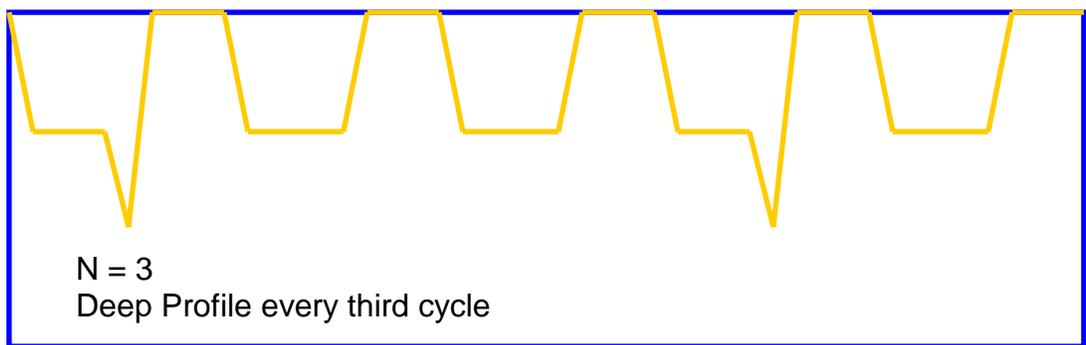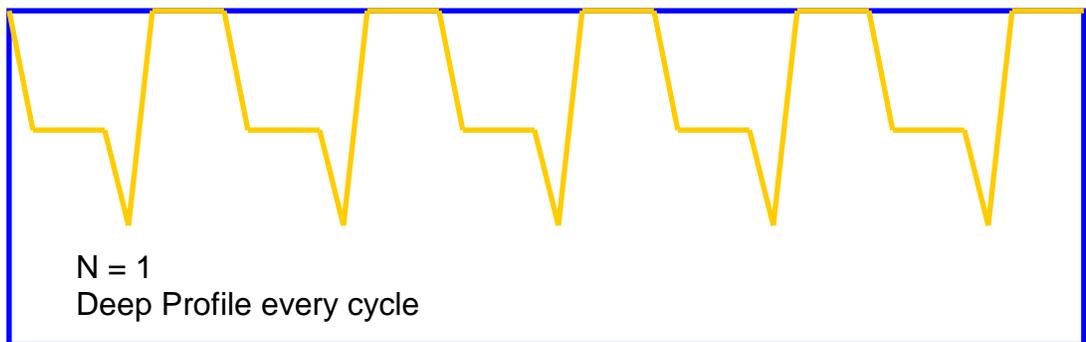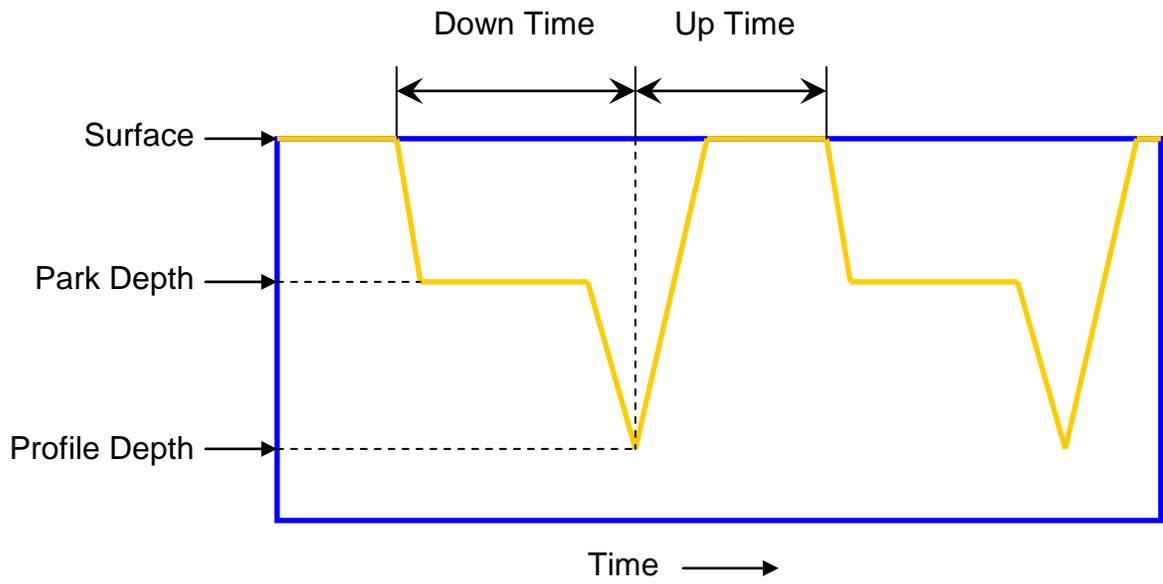
Time

VII. Deep Profile First (DPF)

Independent of the Park and Profile cycle length, the first profile is always a Deep Profile that begins at the Profile Depth. This means the float returns a CTD profile relatively soon, typically less than a day, after the float is deployed. This feature supports comparison of the initial float profile with a conventional CTD cast from the ship.

The first descent begins at the end of the Mission Prelude. A schematic representation of DPF with a Park and Profile parameter N = 2 is shown below.

N = 2 and Deep Profile First (DPF)
Deep Profile on first cycle and every second cycle

Time ⟶
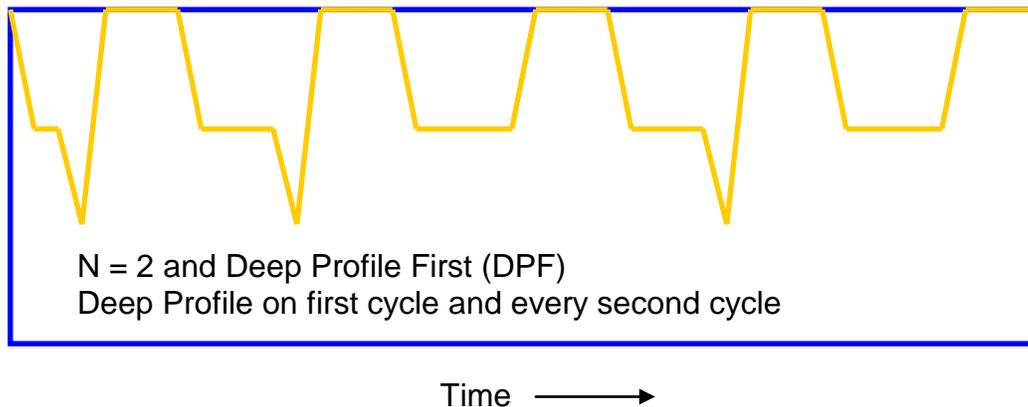
VIII. Air Pump Limits

At the beginning of each telemetry cycle the float verifies that the air bladder is fully inflated. If the pressure does not exceed the threshold, Parameter Mfb, the float will further inflate the bladder, cycling the air pump on for 1 second and off for 1 second until the pressure exceeds the threshold. The use of the air pump is limited to 2000 Volt·seconds during each profile cycle to prevent excessive battery drain in the event of a problem in the air system that prevents full inflation.

The maximum air bladder pressure is higher (6.2 inHg) in the APF9I than in ARGOS equipped floats (5.3 inHg). The higher pressure allows Iridium floats to ride higher at the surface to assure robust connectivity for the Iridium antenna.

IX. Optional Sensors

A. Aanderaa Oxygen Sensor

In addition to SeaBird model 41 CTD sensor, these APEX carry the (optional) Aanderaa Oxygen optode 4330. The oxygen sensor communicates with the APEX controller via RS-232C interface, and provides bphase and Optode temperature via the Argos data stream. From a terminal optode Oxygen in 0µM, temperature, Bphase and Raw Temperature are provided.

The optode measures and presents data in micromole dissolved oxygen per liter (µmol/l). This unit is often also called micromolar (µM). The optode is sampled at the same time as the other sensors, per the depth table. In the case of high density CP profiling this sensor is still sampled per the depth table (see page 33). Bphase is the phase obtained with blue light excitation, which is used to calculate Dphase. 02 concentration can be calculated in micro molar (µM) using the equations found in the Aanderaa users' manual.

NOTE regarding handling: do not lift or pull on the oxygen optode.
NOTE regarding optode salinity: The Apf 9 controller has and will configure the optode for an internal salinity setting of 0.

B. FLBB-AP2 Sensor

The second optional sensor included on these APEX is the combination Fluorometer-Backccattering FLbb-AP2 sensor.

The fluorometer allows the user to monitor chlorophyll concentration by directly measuring the amount of chlorophyll-*a* fluorescence emission from a given volume of water. Chlorophyll, when excited by the presence of an external light source, absorbs light in certain regions of the visible spectrum and re-emits a small portion of this light as fluorescence at longer wavelengths. A blue LED (centered at 470 nm and modulated at 1 kHz) provides the excitation source. The blue light from the sources enters the water volume at an angle of approximately 55– 60 degrees with respect to the end face of the unit. Fluoresced light is received by a detector positioned where the acceptance angle forms a 140-degree intersection with the source beam. A red interference filter is used to discriminate against the scattered blue excitation light. The red fluorescence emitted is synchronously detected by a silicon photodiode. Scattering is measured simultaneously by detecting the scattered light from a 700 nm LED at 140 degrees to the same detector used for fluorescence. The scattering measurement is performed at the same 140 degree angle as the chlorophyll fluorescence.

C. Testing the optional sensors

Sensors can be tested by connecting a terminal, with the provided interface cable, as described in the APEX Final Test Procedure.

Below is an example of output from the Aanderaa oxygen sensor and menu:

\> o ?

Menu of optode functions.

? Print this menu.

Oc Configure the optode.

Od Display the optode configuration.

On Display optode model and serial number.

Op Measure optode power consumption.

Os Get an oxygen sample.

\> o s Optode O,T,BPhase,RawTemp: 259.0uM 23.02C 24.30 144.5

Below is an example of output from the FLbb-AP2 sensor and menu:

\> f ?

Menu of SBE41cp functions.

? Print this menu.

Fc Configure the FLBB.

Ff Display FLBB firmware revision.

Fm Measure power consumption by FLBB.

Fn Query the FLBB for its serial number.

Fs Execute FLBB measurement.

X. Setting the Real-Time Clock

The APF9I is equipped with a real-time clock (RTC). The RTC can be set by the operator to any desired reference time. However, the float will automatically update the RTC each time a GPS fix is obtained if the RTC and the GPS satellite disagree by more than 30 seconds.

As a consequence, APF9I floats will end up running on GMT eventually, so the operator should only set the RTC to GMT to avoid confusion and scheduling problems. This is particularly important if the TOD feature is to be used.

To view or set the RTC, enter the Main Menu (see "Connecting a Terminal" and "APF9I Command Summary") and use the 't' command as shown in the examples below:

Viewing the RTC:

```
> t                                   ← entered by operator followed by [ENTER]
Real time clock: Fri Sep 25 04:47:05 1970
```

Setting the RTC:

```
> t  07/24/2007:17:11:00        ← entered by operator as mm/dd/yyyy:hh:mm:ss
(Sep 25 1970 04:47:45,  393506 sec) ParseTime()         The time
         string represents the date Tue Jul 24 17:11:00 2007
Real time clock: Tue Jul 24 17:11:01 2007
```

The date and time must be entered in the format shown in the example above. The RTC will revert to 1970 if the batteries providing power to the APF9I are disconnected. In this case the operator should reset the RTC after restoring power to the float.

XI.   Time of Day (TOD)

APF9I floats have the option of scheduling profiles so that the float surfaces at a particular time of day (TOD). The APF9I real-time clock is used to dynamically set the end of the Down Time to some user specified number of minutes after midnight. The operator must take into account any difference between the time zone of the deployment and GMT when setting this parameter. **Remember that the RTC of the float will be set to GMT whenever the float obtains a GPS fix, so you cannot control the time zone of the RTC.** This is described in more detail below.

The TOD feature is applied by the float as follows:

- At the start of a descent (end of Up Time), the APF9I computes a Down Time expiration based on the Down Time programmed by the operator.
- If the TOD feature is <u>disabled</u>, the Down Time will expire at that calculated time of the RTC.
  - For example, if the Down Time is set to 120 hours (10 days) and the Up Time ends at 14:00 on July 10, 2007, the next Down Time will expire at 14:00 on July 20, 2007.
- If the TOD feature is <u>enabled</u>, the float extends the Down Time expiration to the next occurrence of "TOD minutes after midnight" on the RTC.
  - For example, if the initial calculation placed the Down Time expiration at 14:00 on July 20, 2007 (as above), but the TOD was enabled and set to 1200 minutes (20 hours after midnight), the Down Time would be extended from 14:00 and set to expire at the next occurrence of 20:00, which is 20:00 on July 20, 2007.

Active ballasting and all other Down Time behaviors continue until the Down Time expires. This will be until 14:00 in the first example and until 20:00 in the second example.

Controlling TOD

The TOD feature must be manually enabled by the operator. This is done by entering the Mission Programming Agent ('m' from Main Menu, see "<u>Connecting a Terminal</u>" and "<u>APF9I Command Summary</u>") and setting Parameter Mtc to an allowed value in minutes. Setting Parameter Mtc to no value will disable the TOD feature.

Enabling TOD

```
> t c 360                          ← entered by operator followed by [ENTER]
The down-time will expire at 360 Minutes after midnight.
```

Disabling TOD

```
> t c                              ← entered by operator followed by [ENTER]
The time-of-day feature has been disabled.
```

Shifting the Time Zone

Because the RTC is necessarily set to GMT, the operator must account for the time zone difference between the float and GMT in setting TOD. For example, assume:

- The float will be deployed in the eastern Pacific (10 hours behind GMT, 12:00 GMT is 02:00 in the eastern Pacific)
- The operator wishes to use the TOD feature to set Down Time expiration to 20:00 in the local time zone

20:00 in the local time zone is 06:00 GMT (10 hours later). Therefore, set TOD to 360 minutes (6 hours). Down Time will expire at 06:00 GMT, which is 20:00 in the local time zone.

Selecting a TOD Value

To select a TOD value, you must first decide what time you wish the float to surface. Then calculate the approximate duration of the profile, which begins with the expiration of the Down Time. The calculation is based on the programmed depth from which the float will ascend and assumes an ascent speed of 0.08 dbar per second.

For example, a 1200 dbar profile requires approximately 4 hours.[1] If you wish to have the float reach the surface at approximately 02:00, set TOD so that the Down Time will expire 4 hours earlier. Four hours earlier is 22:00, which is 1320 minutes after midnight. Therefore set TOD to 1320 minutes.

If profiles are to be conducted from both the Park Depth and the Profile Depth and the operator wishes the float to reach the surface at a consistent time, the Deep-profile descent time, Parameter Mtj, must be set to a reasonable value for the descent from the Park Depth to the Profile Depth. See "Profile Ascent Timing" for additional information.

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[1] (1200 dbar / 0.08 dbar/sec) / 3600 sec/hr = 4.16 hours

XII. Iridium Data

A.   Iridium Service and Costs

Each float operator must obtain an Iridium SIM card (Subscriber Identity Module) for each APF9I float. SIM cards are obtained from an Iridium provider who you will need to locate and choose. Iridium charges can be a significant expense and it is worth shopping for a good rate. There are a number of providers and the list is not restricted because the connection is coming from a float in the ocean.

Teledyne Webb Research uses JouBeh Technologies:

*   http://www.joubeh.com

Some Iridium providers are "data only". This is appropriate for a float and is the type of service for which you should ask. Like the service, the SIM card should also be "data only".

You will need to send the SIM card and the unlocking PIN to Teledyne Webb Research for us to be able to build and test the float. If you do not change the PIN from the factory default value you will not need to provide the PIN. Please keep a record of the SIM card's serial number (ICCID) and phone number (MSISDN). Both numbers are essential and must stay together as a pair. The firmware includes a command, Parameter Hs, to query and display the ICCID and MSISDN of the SIM card. Similarly, please keep a record of the float's Iridium modem (LBT) serial number (IMEI). Parameter Hi will query and display the IMEI of the LBT.

Billing for Iridium service is monthly. Teledyne Webb Research will give you notice 30 days prior to shipment so that you can activate your SIM card. The card must be activated for Teledyne Webb Research to test the float. The monthly cost for a SIM card is typically $30.00 (USD). Calls from the float to the host server are charged by the minute (or fraction there of) at $1.50/minute. Average data transfer rates are in the range 6 Kbytes to 10 Kbytes per minute. Anticipate 20 Kbytes to 50 Kbytes of data for each profile. Typical connection times at the surface are 5 to 10 minutes. Please note that these are approximate costs. Your actual costs will vary with provider and use.

B.   The Float's Iridium Modem and Two-Way Communications

The float's Iridium modem (LBT) is a Model 9522A L-Band Transceiver. Peak RF power during transmission is 7 Watts. The LBT is mounted inside the float and is configured for use by Teledyne Webb Research during production. No user configuration or adjustment is required. Production testing includes full verification of float to host server communications. This is the reason for requiring activation of the SIM card 30 days in advance of shipment. Your reception capabilities must also be in place at that time (see "Modem-to-Modem vs. RUDICS").

When the float surfaces at the end of a profile the LBT is used to "register" with the Iridium system. This verifies that the float is able to see the sky. The float then disconnects from the Iridium system and uses the antenna to acquire a GPS fix. The fix is included in the data file returned to the host server (see "Iridium Data"). The LBT is then used to re-register with the Iridium system, upload hydrographic (10 - 20 Kbytes) and engineering (12 - 25 Kbytes) data files, and download any changes to the mission parameters (< 1 Kbyte).

The download file, mission.cfg, is stored on the host server and can be edited there when it is desirable to change the mission parameters. Each active line in the configuration file has the form:

`ParameterName(argument) [CRC]`

Inactive lines (comments) start with a '#' character. The CRC can be calculated using a Linux based utility, *chkconfig*, which is part of a software package developed at the University of Washington (see "Modem-to-Modem vs. RUDICS"). A mission.cfg template, which includes all of the mission parameters that interact with each other, is shown below (with example value and units, if any, displayed in square brackets):

ActiveRecoveryMode()
AirBladderMaxP(124) [count]
AscentTimeOut(540) [min]
AtDialCmd(ATDT59312) [primary]
AltDialCmd(ATDT63256) [alternate]
BuoyancyNudge(10) [count]
CompensatorHyperRetraction(0) [counts]
ConnectTimeOut(60) [sec]
CpActivationP(985) [dbar]
DeepProfileDescentTime(240) [min]
DeepProfilePistonPos(16) [count]
DeepProfilePressure(2000) [dbar]
DownTime(601) [min]
FlashErase()
FlashCreate()
FloatId(5233)
InitialBuoyanctNudge(22) [count]

MaxLogKb(60) [KByte]
ParkDescentTime(240) [min]
ParkPistonPos(66) [count]
ParkPressure(1000) [dbar]
PnPCycleLen(1)
Pwd(iridium)
TelemetryRetry(15) [min]
TimeOfDay(DISABLED) [min]
UpTime(660) [min]
User(iridium)
Verbosity(2)

The *chkconfig* utility performs parameter sanity checks, so it is a good idea to include all of the commands above so that their safe interaction can be verified before the new configuration is downloaded by the float.

The mission.cfg file should not be empty, but it is sufficient to include only a comment or just a benign command such as **Verbosity(2)** if you do not wish to make any changes. Several of these commands should only be used if absolutely required and then only with caution. For example, DO NOT change both the primary and the alternate dial commands at the same time. Conversely, commands such as **CpActivationP(Decibars)** might be used frequently to adjust the range of high resolution sampling in response to observations of the water column returned by previous profiles.

Given the required UpTime for this job, to ensure that floats ascend to the surface every 5 days (for example, beginning 1st April) include the following line in mission.cfg, starting 1st April:

DownTime(6780) [0x03CA]

To ensure that floats ascend to the surface every 10 days (for example, beginning 1st June), update the line as follows, starting 1st June:

DownTime(13980) [0x6891]

C. Using Modem-to-Modem Communications

Modem-to-modem communication is illustrated in the following figure, which shows a float-installed 9522A Iridium modem communicating with the ground-station Iridium gateway, via an Iridium satellite. The Iridium gateway is then accessed for data by either phone-line (using a host server with a modem) or over the network (using the RUDICS service).

Iridium Satellite

9522A Modem

Phone — Modem

RUDICS — PC

Iridium Ground Station
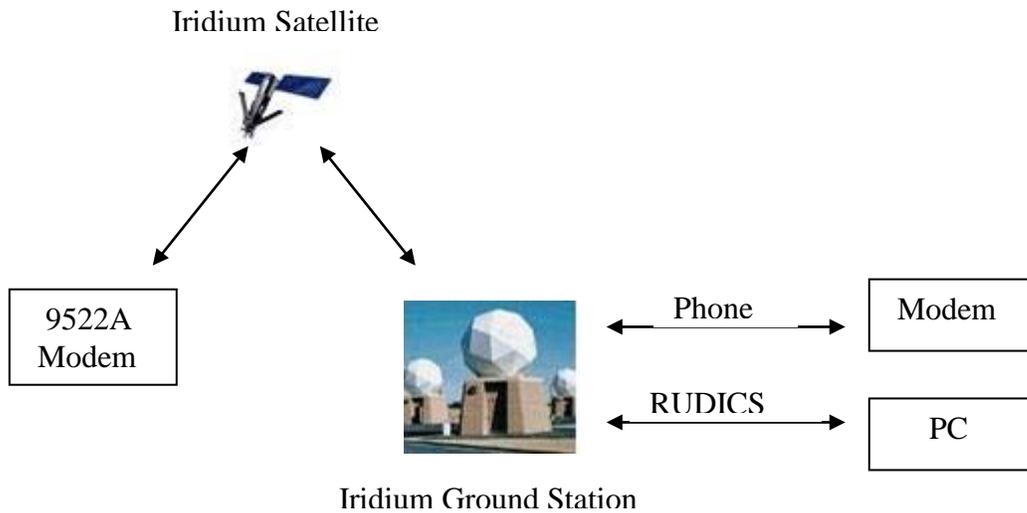
For modem-to-modem communications (without RUDICS) you will need independent primary and alternate host servers, each with a modem connected to the phone system to receive the calls and data from the float. A full description of this equipment and software is beyond the scope of this manual. However, Teledyne Webb Research makes regular use of U.S. Robotics external modems, Model USR3453C, Courier™ 56K Business Modem.

A Linux-based modem-to-modem solution has been developed by Dana Swift at the University of Washington. The software and documentation are available in a "tarball" at no charge; however, it requires some level of Linux expertise on your part to implement. If you are experienced with Linux the process is quite straightforward. You will need to acquire the servers, install and configure Linux, and reconcile any differences between the version of Linux on your host servers and the version of Linux under which the distribution was developed (RedHat Linux 9). The package automates the reception of data messages from multiple floats and fully supports two-way communication. Some user developed documentation of the implementation process is included later in this manual (see "The Remote Unix Host"). Additional Linux based packages for data processing are also available with limited support. Contact Teledyne Webb Research for further information.

An alternative to setting up the modem-to-modem solution yourself, especially if you are not comfortable with Linux or do not wish to set up and maintain host servers, is to contract out the reception of the calls and have the data provided to you by email, FTP, or web server. The contractor is then responsible for maintaining the servers and modems. This is similar to the

long-standing ARGOS system. There are providers available and you may wish to investigate this possibility. Contact Teledyne Webb Research for additional information.

Another alternative to setting up the modem-to-modem solution yourself is to use RUDICS, the *Router-based Unrestricted Digital Internetworking Connectivity Solution*, which is available from several providers (including Iridium Satellite, LLC and NAL Research, Inc). RUDICS is Internet rather than phone based, which provides additional connection redundancy. The float makes calls as before and these are received at the Iridium ground-station. The data are then made available to you using a browser, through a website set up by your RUDICS provider. You do not need to maintain a host server and will only need a computer with broadband Internet access. RUDICS does have a large setup cost, but subsequent data costs and connection times are typically lower compared to other modem-to-modem solutions.

Although APF9I firmware is currently only compatible with modem-to-modem communication, several other Iridium communication modes exist. These include the *Short Burst Data* service (SBD) and the *Short Messaging Service* (SMS). SBD is a simple and efficient bi-directional transport capability used to transfer messages with sizes ranging from zero (a mailbox check) to 1960 bytes for Mobile Originated (MO-SBD) and zero to 1890 bytes for Mobile Terminated (MT-SBD) devices. SBD takes advantage of signals within the existing air interface, without using the dedicated traffic channels. As a result, small amounts of data can be transferred more efficiently than those associated with circuit-switched data calls. SBD messages can be delivered to the end-user using a variety of mechanisms including email and FTP. Alternatively, SMS transfers data messages up to 160 characters in length. SMS is a store-and-forward method of transmitting messages, geared towards mobile devices in which the message from the originator is stored in a central *Short Message Center* before being forwarded to its destination.

D.   Bearer Service Type

The bearer service type (BST) specifies two characteristics of the phone call made from a modem at the Iridium ground station (where the signal from the satellite is received) to the modem on the host server where you are receiving the call and data from the float. These two characteristics of the call from the gateway modem to the server modem are:

- analog (tone) vs. digital (ISDN)
- serial baud rate

The default in many cases is digital. A problem can arise if your local phone company has only a limited number of ISDN lines available. The likely symptom during pre-deployment testing is a report from the float of "No carrier detected". This may occur either before or after a connection is established.

The solution is to force the conversation to be analog. This can be done by embedding a "CBST" command in the Primary and/or Alternate Dial Commands, Parameters Mhp and Mha. A standard dial command has the form:

ATDT0012223334444

ATDT is a command to the modem, 00 is the required calling prefix, and 12223334444 is the phone number of your modem, beginning with the country code. To embed the CBST command, alter the dial command as follows:

AT+CBST=71, 0, 1; DT0012223334444

The first argument of the CBST command, a '71' in the example above, specifies the baud rate according to the table below, which applies to modem version V.110. First argument values from the table (0, 66, 68, 70 and 71) also force the conversation to be analog. Your server modem should be set to match the commanded baud rate (or auto select). The second and third CBST arguments are always '0' and '1'.

CBST	Baud Rate
0,0,1	auto
66,0,1	1200
68,0,1	2400
70,0,1	4800
71,0,1	9600

E.   Iridium Data

Iridium message files end with a ".msg" extension. Each iridium message file consists of blocks of similar data presented in the order that they were collected during the profile cycle. This firmware revision includes six blocks of data:

1) Park-phase PT samples: These are hourly low-power PT samples collected during the park phase of the profile cycle.

2) Low resolution PTSO/FLBB samples: The deep parts of the profile can be represented using low-resolution spot samples collected at predetermined pressures. Low resolution spot sampling in the deep water was implemented as an energy savings measure.

3) High resolution PTS samples: The shallower parts of the profile can be represented with high resolution (ie., 2 decibar) bin-averaged PTS samples. In continuous profiling mode, the CTD samples at 1Hz and stores the data for later binning and averaging.

4) GPS fixes: After the profile is executed and the float reaches the surface, the location of the profile is determined via GPS.

5) Biographical & engineering data: Various kinds of biographical and engineering data are collected at various times during the profile cycle.

Usually, only one telemetry cycle is required to upload the data to the remote host computer. However, sometimes the iridium connection is broken or the quality of the connection is so poor that the float will abort the telemetry attempt, wait a few minutes, and then try again. Data blocks 4 and 5 will be repeated for each telemetry cycle of a given profile.

A description of the format for each of these blocks of data follows.

Park-Phase PT Sample format

   Hourly low-power PT samples are collected during the park phase of the profile cycle. The park phase is also when active ballasting is done.
   Each sample includes the date & time of the sample, the unix epoch (ie., the number of seconds since 00:00:00 on Jan 1, 1970), the mission time (ie., the number of seconds since the start of the current profile cycle), the pressure (decibars), and the temperature (C). For example:

	|----------- date --------|	UnixEpoch	MTime	P	T
ParkPt:	Aug 27 2005 13:28:01	1125149281	21615	999.8	4.1024
ParkPt:	Aug 27 2005 14:27:57	1125152877	25212	1006.8	4.1554
ParkPt:	Aug 27 2005 15:27:57	1125156477	28812	1004.6	4.1710

```
ParkPt:      Aug 27 2005 16:27:57          1125160077  32412          1004.0          4.1775
ParkPt:      Aug 27 2005 17:27:57          1125163677  36012          1000.2          4.1525
ParkPt:      Aug 27 2005 18:27:57          1125167277  39612          1001.0          4.1381
ParkPt:      Aug 27 2005 19:27:57          1125170877  43212          998.6           4.1030
```

Low Resolution PTS / Optode / FLBB Sample format

The SBE41CP that is used on iridium floats has features that enable subsampling of the water column (similar to the SBE41) as well as the ability to bin-average a continuous sampling of the water column. For subsampled data, the values of pressure, temperature, and salinity are not encoded but are given in conventional units (decibars, C, PSU).

The Aanderaa optode does not report the actual oxygen concentration. Instead, it reports various quantities that require additional processing. In this case, the BPhase and optode temperature (C) are reported. The oxygen concentration is obtained by applying the calibration equations to the BPhase and optode temperature. The calibration equations are expressed in terms of calibration coefficients that are specific to individual optodes.

The Wetlabs FLBB reports three ~12-bit channels that represent the output of an analogue-to-digital measurement. The quantities FSig, BbSig, and TSig represent the fluorometer, back-scatter, and temperature channels, respectively. A calibration equation must be applied to these channels in order to obtain chlorophyl concentration, back-scatter, and temperature in engineering units.

For example:

```
$ Discrete samples: 61
$       p        t         s   TPhase      Topt      no3  FSig  BbSig  TSig
   1074.49   3.1208  34.4275    37.34      3.11      nan    52    106   569 (Park Sample)
    999.35   3.1810  34.3676    37.97      3.16     33.1    50    106   569
    949.57   3.2660  34.3401    37.56      3.25     33.1    50    111   569
    901.15   3.3348  34.3111    37.15      3.32     32.9    50    110   569
    851.05   3.4960  34.2855    36.64      3.48     32.1    50    108   569
```

High Resolution PTS Sample format

For continuously sampled data, 2-decibar bins are used for bin-averaging. These data are encoded as three 16-bit integers (PTS) and then an 8-bit integer that represents the number of samples in the bin:

```
# Nov 05 2006 23:38:59 Sbe41cpSerNo[1520] NSample[11134] NBin[495]
00000000000000[2]
002B5CE0885115
003C5CE188511F
00505CE088511E
00645CE088511D
00785CDF88521C
008C5CDF88521B
00A05CDF88511A
00B45CDC88511A
00C85CAD885A1A
00DC5C8D886418
00F05C88886919
01045C88886A19
01185C74887618
012C5C4E88BB15
[snippage...]
2684144D874814
2698145C874D14
```

The first 4-bytes of the encoded sample represents the pressure in centibars. The second 4-bytes represents the temperature in millidegrees. The third 4-bytes represent the salinity in parts per million. The final 2-bytes represent the number of samples collected in the 2dbar pressure bin.

For example, the encoding: 2698145C874D14 represents a bin with (0x14=) 20 samples where the mean pressure was (0x2698=) 988.0dbars, the mean temperature was (0x0EDE=) 3.806C, and the mean salinity was (0x86A0=) 34.464PSU. The PTS values were encoded as 16-bit hex integers according to the functions below.

Integers in square brackets '[]' indicate replicates of the same encoded line. For example, a line that looks like: 00000000000000[2] indicates that there were 2 adjacent lines with the same encoding....all zeros in this case.

Conversion Notes:

The pressure range is -3276.7 dbar to 3276.7 dbar. Hex values 0x7FFF, 0x8000, 0x8001, and 0xFFFF are used to flag out-of-range (and edge-of-range) measurements or are otherwise reserved. Pressures in the range -0.15 dbar to -0.05 dbar are mapped to 0xFFFE → -0.2 dbar.

The temperature range is -4.095 °C to 61.439 °C. Hex values 0xF000, 0xF001, 0xEFFF, and 0xFFFF are used to flag out-of-range (and edge-of-range) measurements or are otherwise reserved. Temperatures in the range -0.0015 °C to -0.0005 °C are mapped to 0xFFFE → -0.002 °C.

The salinity range is -4.095 psu to 61.439 psu. Hex values 0xF000, 0xF001, 0xEFFF, and 0xFFFF are used to flag out-of-range (and edge-of-range) measurements or are otherwise reserved. Salinities in the range -0.0015 psu to -0.0005 psu are mapped to 0xFFFE → 65.534 psu.

To convert the hex values in an Iridium message file to physical units, proceed as described in the table below. The initial conversion from Hexadecimal to Decimal should assume the hex value is an unsigned integer with a range of 0 to 65535.

Measurement	Hexadecimal [Decimal comparison]	Decimal and Conversion Steps	Physical Result
Pressure ≥ 0	0x1D4C (≤ 0x7FFF) → [7500 (≤ 32767)]	P = 7500 P / 10 →	750.0 dbar
Pressure < 0	0xFFFA (≥ 0x8001) → [65530 (≥ 32769)]	P = 65530 (P - 65536) / 10 →	-0.6 dbar
Temperature ≥ 0	0x3EA6 (≤ 0xEFFF) → [16038 (≤ 61439)]	T = 16038 T / 1000 →	16.038 °C
Temperature < 0	0xF58B (≥ 0xF001) → [62859 (61441)]	T = 62859 (T - 65536) / 1000 →	-2.677 °C
Salinity ≥ 0	0x8FDD (≤ 0xEFFF) → [36829 (≤ 61439)]	S = 36829 S / 1000 →	36.829 psu
Salinity < 0	0xFF9C (≥ 0xF001) → [65436 (≥ 61441)]	S = 65436 (S - 65536) / 1000 →	-0.100 psu
Oxygen ≥ 0	0x0FDA (≤ 0xEFFF) → [4058 (≤ 61439)]	O = 4058	4058 Hz
Oxygen < 0	0xFF9C (≥ 0xF001) → [65436 (≥ 61441)]	O = 65436 (O - 65536) →	-1000 Hz

GPS Fixes

Before each telemetry cycle the float attempts to acquire a GPS fix. An example of a successful fix, as reported in an Iridium message file, is shown below. The information includes the latitude and longitude of the float, time required to obtain the location, the date and time the information was acquired, and the number of satellites used. Longitude is positive in the eastern hemisphere and negative in the western hemisphere. Latitude is positive in the northern hemisphere and negative in the southern hemisphere. Date and time are presented in the format shown in the example.

```
# GPS fix obtained in 98 seconds.
#       lon     lat mm/dd/yyyy hhmmss nsat
Fix: -152.945  22.544 09/01/2005 104710    8
```

If the float is not able to obtain a GPS fix this block of the message file will instead contain the message below:

```
# Attempt to get GPS fix failed after 600 seconds.
```

Biographical and Engineering Data

The biographical and engineering data occupy the last block in the Iridium message file. These data have the form "key"="value". An example is shown below.

```
ActiveBallastAdjustments=5
AirBladderPressure=119
AirPumpAmps=91
AirPumpVolts=192
BuoyancyPumpOnTime=1539
```

Interpretation of this information requires detailed knowledge of the firmware. A full description is beyond the scope of this manual. Contact Teledyne Webb Research for assistance. General conversions for voltage, current and vacuum are provide below.

Volts	V	8 bits unsigned	$V = (V_{raw} * 0.077 + 0.486)$
Current	MA	8 bits unsigned	$I = (I_{raw} * 4.052) - 3.606$
Vacuum	InHg	8 bits unsigned	$V = (V_{raw} * 0.293) - 29.767$

F.   Pressure Table for PTS Samples

Depth Table 67, below, with values expressed in decibars (dbar), defines where PTS measurements are acquired during a profile.

2000	1400	1100	800	500	280	180	120	60	25
1900	1350	1050	750	450	260	170	110	50	20
1800	1300	1000	700	400	240	160	100	45	15
1700	1250	950	650	360	220	150	90	40	10
1600	1200	900	600	330	200	140	80	35	4 or surf
1500	1150	850	550	300	190	130	70	30	

To prevent fouling of the CTD by surface and near-surface contaminants, the shallowest PTS sample is taken when the pressure is between 6 dbar and 4 dbar.

G.   The Remote UNIX Host

This iridium implementation uses a modem-to-modem communications model. The float initiates a telephone call to a remote host computer, logs into the remote host with a username and password, executes a sequence of commands to transfer data, and then logs out. The communications session is float-driven

With respect to the remote host, there is no difference between the float logging in and a human logging in. The communications session is initiated and fully controlled by the float. On the other hand, the float is not naturally adaptable or interactive like a human would be and so an unusual amount of fault tolerance has been built into both sides of the communications session.

An important fault tolerance measure is redundancy in the form of two similarly configured remote hosts each with its own dedicated telephone line. This is optional but recommended. Ideally, these two remote hosts should be separated far enough from each other that power outages or telephone outages are not likely to simultaneously affect both remote hosts. The float firmware is designed to automatically switch to the alternate remote host if with the primary remote host appears to be out of service.

System Requirements

This iridium implementation is strongly tied to the use of a UNIX computer as the remote host (ie., Microsoft operating systems are not suitable). The most important "system requirement" is a system administrator that is familiar, comfortable, and competent in a UNIX environment. While many different flavors of UNIX could be made to work, development was done using RedHat Linux (versions 7-9). RedHat Linux (version 9) will be assumed for the remainder of this section.

The **mgetty** package must be installed and configured to monitor a Hayes-compatible external modem attached to one of the serial ports. For information on how to install and configure the **mgetty** package, refer to the **mgetty** documentation supplied with RedHat Linux. If you customize the login prompt, make sure that it includes the phrase "login:". Similarly, make sure that the password prompt includes the phrase "Password:". The float will not successfully log in if these two phrases are not present.

Once **mgetty** is installed and configured properly, you should be able to log into the remote host via a modem-to-modem connection from another computer. You should test this using the following communications parameters: 4800baud, no parity, 8-bit data, 1 stop-bit.

Remote Host Set Up

Once each telemetry cycle, the float downloads "mission.cfg" from the home directory where the float logs in and this new mission configuration becomes active as the last step before the

telemetry cycle terminates. In the context of a UNIX environment, this simple mechanism allows for great flexibility for remotely controlling floats individually, in groups, or fleet-wise. It is also flexible in that it is possible to switch which model is used even after floats have been deployed. Finally, a UNIX-based remote host facilitates easy speciation of floats as well as for new float developments with no requirement for backward compatibility.

Setting up the Default User on the Remote Host

Another fault tolerance measure requires creation of a *default user* on the remote host. Begin by creating a new *iridium* group to which the *default user* and all floats will belong. As root, execute the command:

> *groupadd -g1000 iridium*

Next, create an account for the *default user* using *iridium* as the username:

> *adduser -s/bin/tcsh –c "Iridium~Apex~Drifter" –g "iridium"*
> *-u1000 -d/home/iridium iridium*

Then give the new user a password by executing (as root):

> *passwd iridium*

For the convenience of the float manager, you might also want to change the permissions on the float's home directory:

> chmod 750 ~iridium

The file, /etc/passwd, will contain the following entry:

```
 iridium:x:1000:1000:Iridium Apex Drifter:/home/iridium:/bin/tcsh
```

The remainder of the set-up for this float should be done while logged into the remote host as the default user (ie., *iridium*). Create two directories:

> mkdir -/bin -/logs

and populate the -/bin directory with the *SwiftWare* xmodem utilities **rx** and **sx** as well as the **chkconfig** utility. These three files are in the **support** directory of your distribution.

Finally, use **emacs** to create the following three ascii files: .**cshrc**, .**rxrc**, and .**sxrc**:

.**cshrc**: This file configures the t-shell at login time. You can modify the configuration to suit yourself so long as your customizations do not interfere with the effects that the three commands below have. In particular, it is important that the float's **bin** directory be in the *path* before any

of the system directories. This will ensure that the float's version of the utilities **chkconfig**, **rx**, and **sx** will be used rather than the system's utilities with these same names.

```
# set the hostname
set hostname=`hostname`

# add directories for local commands
set path = (. ~/bin /bin /sbin /usr/sbin /usr/local/bin)

# set the prompt
set prompt=""$hostname":[$cwd]> "
```

.**rxrc**: This is the configuration file for the *SwiftWare* implementation the xmodem receive utility. *SwiftWare* implements the standard xmodem protocol except that a nonstandard 16-bit CRC is used. Beware that the float will not be able to transfer any hydrographic or engineering data to the remote host using the system version of **rx**. Make sure that the *LogPath* references the *default user's* **logs** directory or else potentially valuable logging/debugging information will be irretrievably lost.

```
# This is the configuration file for 'rx', the
# SwiftWare xmodem receive utility.

# set the default debug level (range: 0-4)
Verbosity=5

# specify the name of the log file
LogPath=/home/iridium/logs/rxlog

# enable (AutoLog!=0) or disable (AutoLog==0)
# the auto-log feature
AutoLog=1

# specify ascii mode (BinaryMode==0) or
# binary mode (BinaryMode!=0)
BinaryMode=0

# specify CRC mode (16bit or 8bit)
CrcMode=16bit
```

.**sxrc**: This is the configuration file for the *SwiftWare* implementation the xmodem send utility. *SwiftWare* **sx** implements the standard xmodem protocol except that a nonstandard 16-bit CRC is used. Beware that new mission configurations will not be downloaded from the remote host to the float if system version of **sx** is used. Make sure that the *LogPath* references the *default user's* **logs** directory or else potentially valuable logging/debugging information will be irretrievably lost.

```
# This is the configuration file for 'sx', the
# SwiftWare xmodem send utility.
```

```
# set the default debug level (range: 0-4)
Verbosity=5

# specify the name of the log file
LogPath=/home/iridium/logs/sxlog

# enable (AutoLog!=0) or disable (AutoLog==0)
# the auto-log feature
AutoLog=1

# specify fixed packet type (128b or 1k)
# PktType=1k
```

Setting up the Remote Host for Individualized Remote Control

The ability to individualize each float is implemented by each float having its own account on the remote host. The steps to set up the remote host are analagous to those for setting up the *default user*. For example, to create an account for float 5047 make sure the **iridium** group exists and then execute the following command (as root):

  adduser -s/bin/tcsh –c "Iridium~Apex~Drifter" –g "iridium" -u15047 -d/home/f5047 f5047

Then give the new user a password and change the permissions of the float's home directory as shown for the *default user*. **Be sure to configure the float to use this username and password.** The file, /etc/passwd, will contain the following entry:

```
    f5047:x:15047:1000:Iridium Apex Drifter:/home/f5047:/bin/tcsh
```

The remainder of the set-up for this float follows very closely that of the *default user* and should be done while logged into the remote host as the float (ie., *f5047*). Create **bin** and **logs** directories in the float's home directory and populate the **bin** directory with the *SwiftWare* xmodem utilities **rx** and **sx** as well as the **chkconfig** utility.

Finally, copy the three ascii files .**cshrc**, .**rxrc**, and .**sxrc** from the *default user's* home directory to the float's home directory. Be sure to edit these files so that the *LogPath* points to the float's **logs** directory or else potentially valuable logging/debugging information will be irretrievably lost.

Setting up the Remote Host for Fleet-Wise Remote Control

The flexibility inherent with individualized float control necessarily increases the level of operational management required - each float has to be considered and controlled individually. However, fleet-wise management of floats is also made possible by configuring the float to use a fleet-wise username. This is in contrast to configuring each float with a unique username (based

on the float serial number). The steps to set up the remote host for fleet-wise control are virtually the same as those for setting up the remote host for a default user, except that the username and password are fleet-wise parameters. Be sure to configure each float in the fleet with the fleet-wise username and password.

Iridium Serial Number Handling

The SIM phone book is programmed with the phone number assigned to the SIM (MSISDN) Mobile System Integrated Services Digital Network and the SIM ID number (ICCID) Integrated Circuit Card Identification. The firmware will be able to query the LBT because it cannot be done through the standard AT commands. This protects against SIM cards being swapped between floats. If a float fails after deployment, there is a record of which SIM card is coupled to a particular float that allows the SIM card to be deactivated.

This information can be programmed using a terminal emulation program (19200 N-8-1), LBT test fixture and the following commands:

```
1. AT (wait 60 seconds)
2. AT+CPBS="SM"
3. AT+CPBW=101,"<CCID>",129,"<MSISDN>"
4. AT+CPBS?
5. AT+CPBR=101 (to verify)
```

where <CCID> and <MSISDN> are actual values.
Note: If the PIN needs to be set, use the following command: `AT+CPIN="<PIN>".`

GPS, LBT, Remote Host Testing

After connecting to an iridium antenna, enter sail commands via a terminal emulation program (9600 8-N-1). Press any key to enter command mode ">" prompt.

```
gc (configure the GPS)
gp (access satellites and set the real time clock)
gf (get a GPS fix)
hc (configure the Iridium modem)
r (activate recovery mode where a GPS fix is followed by an
Iridium call and once a connection established, upload
mission.cfg and download log information to the remote host.)
k (when complete, kill mission by responding with a "y")
```

Appendix A: Storage conditions

For optimum battery life, floats should be stored in a controlled environment in which the temperature is restricted to the range +10 °C to +25 °C. When activated, the floats should be equilibrated at a temperature between -2 °C and +54 °C before proceeding with a deployment.

If the optional VOS or aircraft deployment containers are used, they must be kept dry, and should only be stored indoors.

Appendix B: Connecting a Terminal

The float can be programmed and tested by an operator using a 20 mA current loop and a terminal program. The current loop has no polarity. Connections should be made through the hull ground and a connector or fitting that is electrically isolated from the hull. This is shown in the image below. In this case one side of the current loop is clipped to the zinc anode and the other is clipped to the pressure port.

The communications cables and clamps are included in the float shipment. An RS-232 to current-loop converter is provided with the communications cables. This converter requires a 12 VDC supply.

The RS-232 communications cable should be connected to the COM port of a PC. Run a communications program such as ProComm or HyperTerminal on the PC. Both programs can be downloaded from various Internet sites. HyperTerminal is generally included with distributions of the Windows Operating System.

COM Port Settings: 9600, 8, N, 1
- 9600 baud
- 8 data bits
- No parity
- 1 stop bit
- no flow control / no handshaking
- full duplex

Teledyne Webb Research recommends the practice of capturing and archiving a log file of all communications with each float. If in doubt about a test, email the log file to your chief scientist and/or to Teledyne Webb Research.

Once you have started the communications program and completed the connections described above, press [ENTER] to wake the float from Hibernate mode. The float will respond that it has detected an "asynchronous wake-up" and will enter Command mode. Press [ENTER] in Command mode to display the main menu. Menu selections are not case sensitive. See "APF9I Command Summary" for a complete list of available commands.

Appendix C: APF9I Command Summary

Uppercase commands are used here for clarity; however, APF9I commands are not case sensitive. The menus presented below were copied verbatim from a terminal session with an APF9I controller. ">" is the APF9I prompt for operator input. The first menu is displayed in response to either a question mark ("?") or the [ENTER] when no preceding command is entered.

IMPORTANT: Do not update the logging verbosity level that the float is initially shipped with.

IMPORTANT: Piston full extension, set with menu parameter Ff, is calibrated and set at the factory. Do not alter the value of Ff shown in the "Missions" appendix. Using a value larger than the factory setting may result in severe damage to the pump.

Main Menu (Command Mode)

> ?
Menu selections are not case sensitive.
? Print this help menu.
A Initiate pressure-activation of mission.
B Get a full P T S O T2 scan.
C Calibrate: battery volts, current, & vacuum.
D Set logging verbosity. [0-5]
E Execute (activate) mission.
F CDOM module agent.
F? CDOM module agent menu.
G GPS module agent.
G? GPS module menu.
H LBT module agent.
H? LBT module menu.
I Diagnostics agent.
I? Diagnostics menu.
J FLASH file system agent.
J? FLASH file system menu.
K Kill (deactivate) mission.
L List mission parameters.
M Mission programming agent.
M? Mission programming menu.
N Display float serial number.
O Optode oxygen sensor agent.
O? Optode oxygen sensor menu.
P Display the pressure table.
Q Exit command mode.

R Activate recovery mode.
S Sensor module agent.
S? Sensor module menu.
T Get/Set RTC time. (format 'mm/dd/yyyy:hh:mm:ss')
U Attach the logstream to a specified file.
V Close the log file.

The sub-menus shown below, CDOM (F?), GPS (G?), LBT (H?), File System (J?), CTD (S?), and System Diagnostics (I?), are all accessible from the Main Menu (Command Mode) using the appropriate letter and question mark combination. The float remains in command mode when displaying these sub-menus, so the Main Menu commands remain active. Entering the Mission programming agent (M), however, exits from command mode until you quit (Q) the Mission Programming Agent. List Mission Parameters (L) is an active command in both Command Mode and the Mission Programming Agent.

Command Mode Sub-Menus

FLBB Menu

```
> F ?
Menu of SBE41cp functions.
?  Print this menu.
Fc Configure the FLBB.
Ff Display FLBB firmware revision.
Fm Measure power consumption by FLBB.
Fn Query the FLBB for its serial number.
Fs Execute FLBB measurement.
Fw Query the FLBB for its wavelengths.
```

GPS Menu

```
> G ?
Menu of Garmin GPS15L-W functions.
?  Print this menu.
Ga Upload almanac to GPS15L-W.
Gc Configure the GPS15L-W.
Gf Get GPS15L-W fix.
Gl Log NMEA sentences from GPS15L-W.
Gt Synchronize the Apf9 clock with GPS.
```

LBT Menu (Iridium Modem)

```
> H ?
Menu of modem functions.
?  Print this menu.
Hb LBT signal strength (bars).
Hc Configure the modem.
Hf Query modem's firmware revision.
Hi Query modem's IMEI number.
Hm Query modem's model.
Hr Register the LBT with the Iridium system.
Hs Query SIM card's ICCID & MSISDN numbers.
```

FLASH File System Menu

```
> J ?
Menu of FLASH file system functions.
?  Print this menu.
Jb Print bad-block list.
Jc Create FLASH file system (destructive).
Jd Print the FLASH chip identifier.
Je Erase the FLASH file system (destructive).
Jl Print directory listing of FLASH file system.
Jp Print a file to the screen.
Jr Report FLASH errors since file system creation.
```

```
Ju Upload files to the iridium server.
Jz Reset FLASH error counters to zero.
```

Command Mode Sub-Menus (continued)

Sensor Menu (Seabird SBE-41cp)

```
> S ?
Menu of SBE41cp functions.
?  Print this menu.
Sa Activate CP mode.
Sb Bin-average CP data.
Sc Display the SBE41cp calibration coefficients.
Sd Deactivate CP mode.
Sf Display SBE41cp firmware revision.
Sg Enter SBE41cp gateway mode.
Sk Configure the SBE41cp.
Sm Measure power consumption by SBE41cp.
Sn Display SBE41cp serial number.
Sp Get SBE41cp pressure.
Ss Get SBE41cp P T S & O.
St Get SBE41cp P & T (low-power).
Su Upload CP data.
```

System Diagnostics Menu

```
> I ?
Menu of diagnostics.
?  Print this menu.
a  Run air pump for 6 seconds.
b  Move piston to the pressure activation position.
c  Close air valve.
d  Display piston position
e  Extend the piston 4 counts.
f  Freeze into inactive mode.
g  Goto a specified position. [1-254] (counts)
l  Set maximum engineering log size. [5-63] (KB)
o  Open air valve.
r  Retract the piston 4 counts.
s  Execute the SelfTest().
t  Calculate ToD down-time expiration.
```

Mission Programming Agent

The interaction recorded below shows the operator entering the Mission Programming Agent from Command Mode (M), displaying the available commands (?), and quitting the agent (Q) to return to Command Mode. Note that the system performs sanity checks on the mission parameters when leaving the Mission Programming Agent. Warnings will be displayed if problems are detected.

```
> M Entering Mission Programming Agent
> ?
Menu selections are not case sensitive.
?  Print this menu.
B  Buoyancy control  agent.
B? Bouyancy control  menue.
C  Continuous profile activation pressure (decibars).
F  Float vitals agent.
F? Float vitals menu.
H  Host configuration agent.
H? Host configuration menu.
J  Deep-profile pressure. (0-2000] (decibars)
K  Park pressure. (0-2000] (decibars)
L  List mission parameters.
N  Park and profile cycle length. [1-254]
Q  Quit the mission programming agent.
S  Sample mode for FLBB. [0=Disable, 1=Enable]
T  Mission timing agent.
T? Mission timing menu.
Z  Analyze the current mission programming.
> Q
All constraints and sanity checks passed.
Quiting Mission Programming Agent.
>
```

Listing Mission Parameters

```
> L
User:  ...
Pwd:   ...
Pri:   ...                                                  Mhp
Alt:                                                        Mha
ENABLE FLBB sample mode.                                    Ms
INACTV ToD for down-time expiration. (Minutes)              Mtc
 13740 Down time. (Minutes)                                 Mtd
 00660 Up time. (Minutes)                                   Mtu
 00540 Ascent time-out. (Minutes)                           Mta
 00270 Deep-profile descent time. (Minutes)                 Mtj
 00330 Park descent time. (Minutes)                         Mtk
 00360 Mission prelude. (Minutes)                           Mtp
 00015 Telemetry retry interval. (Minutes)                  Mhr
 00060 Host-connect time-out. (Seconds)                     Mht
  2000 Continuous profile activation. (Decibars)            Mc
  1200 Park pressure. (Decibars)                            Mk
  2000 Deep-profile pressure. (Decibars)                    Mj
   056 Park piston position. (Counts)                       Mbp
   000 Compensator hyper-retraction. (Counts)               Mbh
   016 Deep-profile piston position. (Counts)               Mbj
   010 Ascent buoyancy nudge. (Counts)                      Mbn
   022 Initial buoyancy nudge. (Counts)                     Mbi
   001 Park-n-profile cycle length.                         Mn
   124 Maximum air bladder pressure. (Counts)               Mfb
   096 OK vacuum threshold. (Counts)                        Mfv
   227 Piston full extension. (Counts)                      Mff
   016 P-Activation piston position. (Counts)               Mfs
     2 Logging verbosity. [0-5]                             D
  0002 DebugBits.                                           D
```

Note that Mission Parameters are changed by entering the Mission Programming Agent (M) from the Main Menu (Command Mode).

Appendix D: Mission Parameters

<u>IMPORTANT</u>: Do not update the logging verbosity level that the float is initially shipped with.

<u>IMPORTANT</u>: Piston full extension, set with menu parameter Ff, is calibrated and set at the factory. Do not alter the value of Ff shown in the "Missions" appendix. Using a value larger than the factory setting may result in severe damage to the pump.

ActivateRecoveryMode ....   Induce the float into recovery mode and initiate telemetry at regular intervals given by the TelemetryRetry. No argument is required and the argument, if present, is ignored.

AirBladderMaxP .... The cut-off pressure (in A/D counts) for air-bladder inflation. The air pump will be deactivated when the air bladder pressure exceeds the cut-off. The valid range is 1 to 240 counts.

AscentTimeOut .... The initial segment of the uptime that is designated for profiling and vertical ascent. If the surface has not been detected by the time this timeout expires then the profile will be aborted and the telemetry phase will begin. The valid range is 1 minute to 10 hours.

AtDialCmd .... The modem AT dialstring used to connect to the primary host computer.

AltDialCmd .... The modem AT dialstring used to connect to the alternate host computer.

BuoyancyNudge .... The piston extension (counts) applied each time the ascent rate falls below the user-specified minimum. This adds buoyancy to the float in order to maintain the ascent rate.

CompensatorHyperRetraction Floats with N2-compensators require the piston to be hyper-retracted in order to descend from the surface to the park

level. The valid range is 0-254 counts.

ConnectTimeOut .... The number of seconds allowed after dialing
for a connection to be established with the
host computer. The valid range is 30-300
sec.

CpActivationP   The pressure where the control firmware transitions from
subsampling the water
column (in the deep water) to where the CP
mode of the SBE41cp is activated for a high
resolution profile to the surface.

Important note: The SBE41CP is not designed
for subsampling in the presence of
significant temperature gradients. The
pump period for spot samples is
insufficient to drive thermal mass errors
own to an acceptable level.

DeepProfileDescentTime ... This time determines the maximum amount of
time allowed for the float to descent from
the park pressure to the deep profile
pressure. The deep profile is initiated
when the DeepProfileDescentTime expires or
else the float reaches the deep profile
pressure, whichever occurs first. The
valid range is 0-8 hours.

DeepProfilePistonPos ..... The control firmware retracts the piston to
the DeepProfilePistonPos in order to
descend from the park pressure to the deep
profile pressure. The DeepProfilePistonPos
should be set so that the float can reach
the deep profile pressure before the deep
profile descent period expires. The valid
range is 1-254 counts.

DeepProfilePressure ...... This is the target pressure for deep
profiles. The valid range is 0-2000 dbar.

DownTime .... This determines the length of time that the
float drifts at the park pressure before
initiating a profile. The valid range is 1
min to 30 days.

FlashErase .... This command requires no argument and causes the FLASH memory chip to be reformatted. WARNING: All contents of the FLASH file system will be destroyed.

FlashCreate .... This command requires no argument and causes the FLASH file system to be reinitialized. This command is time consuming (~30 minutes) and energy-expensive. The process involves writing a test pattern to each 8KB block of the FLASH ram and then re-reading the contents to ensure that the test pattern matches what was written. If bad blocks are discovered then they are added to a bad-block list. Blocks identified in the bad block list are not used for storage. WARNING: All contents of the FLASH file system will be destroyed.

FloatId .... The float identifier.

InitialBuoyancyNudge ......The piston extension (counts) applied in order to initiate the vertical ascent at the beginning of the profile. This same nudge is also applied at the end of the profile to make sure the float reaches the surface.

MaxLogKb .... The maximum size of the logfile in Kilobytes. Once the log grows beyond this size, logging is inhibited and the logfile will be automatically deleted at the start of the next profile. The valid range is 5-60KB.

ParkDescentTime .... This time determines the maximum amount of time allowed for the float to descent from the surface to the park pressure. The active ballasting phase is initiated when the ParkDescentTime expires. The valid range is 0-8 hours.

ParkPistonPos ....   The control firmware retracts the piston to
                             the ParkPistonPos in order to descend from
                             the surface to the park pressure. The
                             ParkPistonPos should be set so that the
                             float will become neutrally buoyant at the
                             park pressure. The valid range is 1-254
                             counts.

ParkPressure ....   This is the target pressure for the active
                             ballasting algorithm during the park phase
                             of the mission cycle. The valid range is
                             0-2000 dbar.

PnPCycleLen ....   A deep profile is initiated when the
                             profile id is an integral multiple of
                             PnPCycleLen. All other profiles will be
                             collected from the park pressure to the
                             surface.

Pwd ....   The password used to login to the host
                             computer.

TelemetryRetry ....   This determines the time period between
                             attempts to successfully complete telemetry
                             tasks after each profile. The valid range
                             is 1 minute to 6 hours.

TimeOfDay ....   This allows the user to specify that the
                             down-time should expire at a specific time
                             of day (ToD). The ToD feature allows the
                             user to schedule profiles to happen at
                             night (for example).

                             The ToD is expressed as the number of
                             minutes after midnight (GMT). The valid
                             range is 0-1439 minutes. Any value outside
                             this range will cause the ToD feature to be
                             disabled.

UpTime ....   This determines the maximum amount time
                             allowed to execute the profile and complete
                             telemetry. The valid range is 1 minute to
                             1 day.

User ....   The login name on the host computer that

the float uses to upload and download data. itself.

Verbosity ....   An integer in the range [0,4] that determines the logging verbosity with lower values producing more terse logging. A verbosity of 2 yields standard logging.

Appendix E: Returning APEX floats for factory repair or refurbishment

Contact Teledyne Webb Research before returning APEX floats for repair or refurbishment. All returns from outside USA, please specify our import broker:

Consignee: Teledyne Webb Research
                49 Edgerton Drive
                North Falmouth, MA 02536

Note on shipping documents: US MADE GOODS

CAUTION: If the float was recovered from the ocean, it may contain water, which presents a safety hazard due to possible chemical reaction of batteries in water. The reaction may generate explosive gases (see "Alkaline Battery Warning" at the beginning of this manual).   In this case, be sure to remove the seal plug to ventilate the instrument before shipping. Do this is a well ventilated location and do not lean over the seal plug while loosening it. Use a 3/16 inch hex wrench, or pliers, to rotate the plug counter-clockwise.

Seal Plug

Appendix F: Missions

This section lists the parameters for each float covered by this manual.
To display the parameter list, connect a communications cable to the float, press <ENTER> to wake the float from hibernate and start command mode, and press 'l' or 'L' to list the parameters.
See "Connecting a Terminal" and "APF9I Command Summary" for more information.

INSTRUMENT # 7562

```
APEX version 102815   sn 2347
User:  f7562
Pwd:   0x6f1e
Pri:   AT+CBST=71,0,1;DT00881600005155          Mhp
Alt:   ATDT0033561393749                         Mha
ENABLE FLBB sample mode.                         Ms
INACTV ToD for down-time expiration. (Minutes)   Mtc
 13740 Down time. (Minutes)                      Mtd
 00660 Up time. (Minutes)                        Mtu
 00540 Ascent time-out. (Minutes)                Mta
 00300 Deep-profile descent time. (Minutes)      Mtj
 00300 Park descent time. (Minutes)              Mtk
 00360 Mission prelude. (Minutes)                Mtp
 00015 Telemetry retry interval. (Minutes)       Mhr
 00060 Host-connect time-out. (Seconds)          Mht
  2000 Continuous profile activation. (Decibars) Mc
  1000 Park pressure. (Decibars)                 Mk
  2000 Deep-profile pressure. (Decibars)         Mj
   066 Park piston position. (Counts)            Mbp
   000 Compensator hyper-retraction. (Counts)    Mbh
   016 Deep-profile piston position. (Counts)    Mbj
   010 Ascent buoyancy nudge. (Counts)           Mbn
   022 Initial buoyancy nudge. (Counts)          Mbi
   001 Park-n-profile cycle length.              Mn
   124 Maximum air bladder pressure. (Counts)    Mfb
   096 OK vacuum threshold. (Counts)             Mfv
   226 Piston full extension. (Counts)           Mff
   016 P-Activation piston position. (Counts)    Mfs
     2 Logging verbosity. [0-5]                   D
  0002 DebugBits.                                 D
  9570 Mission signature (hex).
```